#4

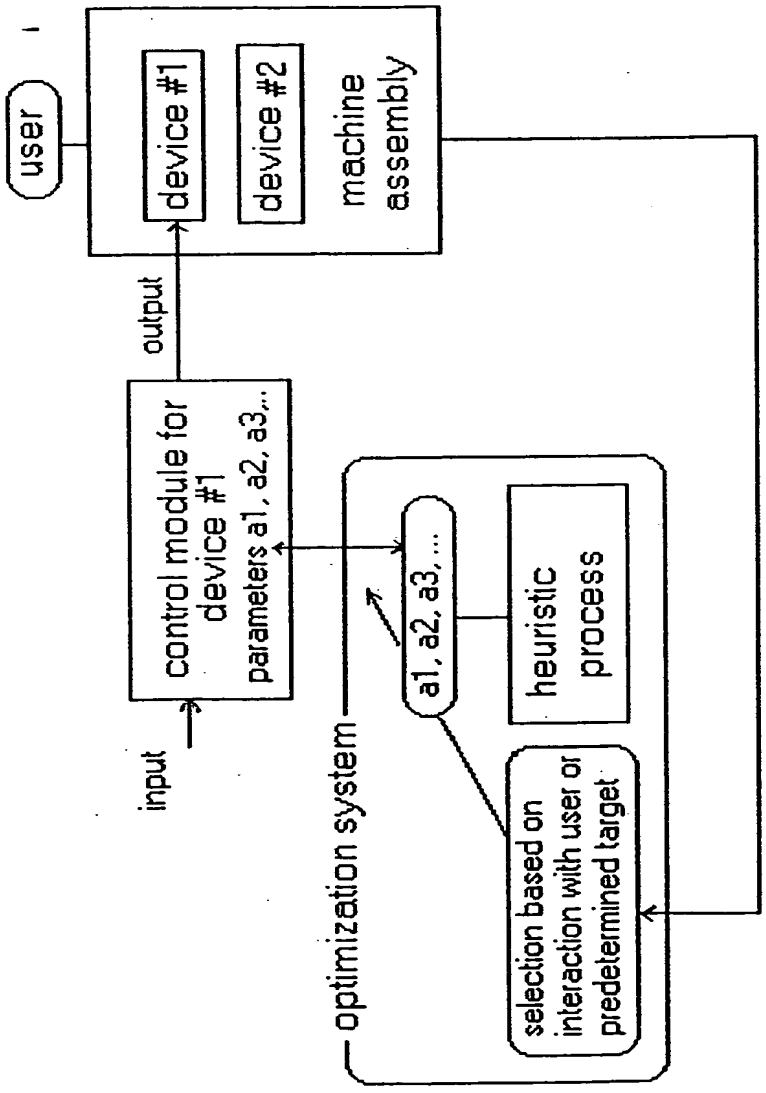

user
machine assembly
device #1
device #2
output
control module for device #1 parameters a1, a2, a3,...
input
optimization system
a1, a2, a3, ...
heuristic process
selection based on interaction with user or predetermined target

Fig. 1a

Fig. 1b

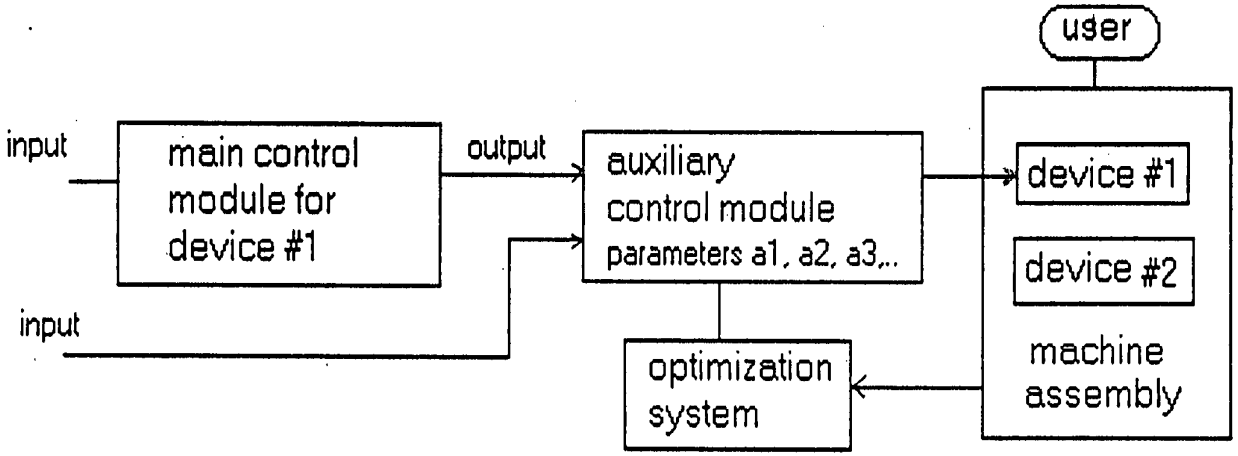

user
input
main control module for device #1
output
auxiliary control module
parameters a1, a2, a3,..
device #1
device #2
machine assembly
input
optimization system

Fig. 1c

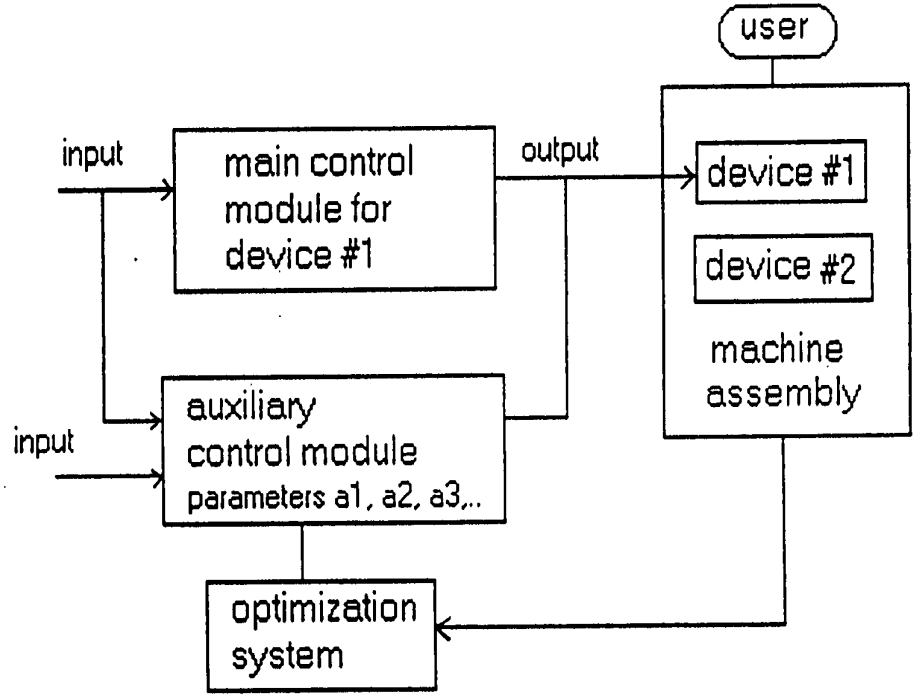

user
input
main control module for device #1
output
device #1
device #2
machine assembly
input
auxiliary control module
parameters a1, a2, a3,..
optimization system

Fig. 1d

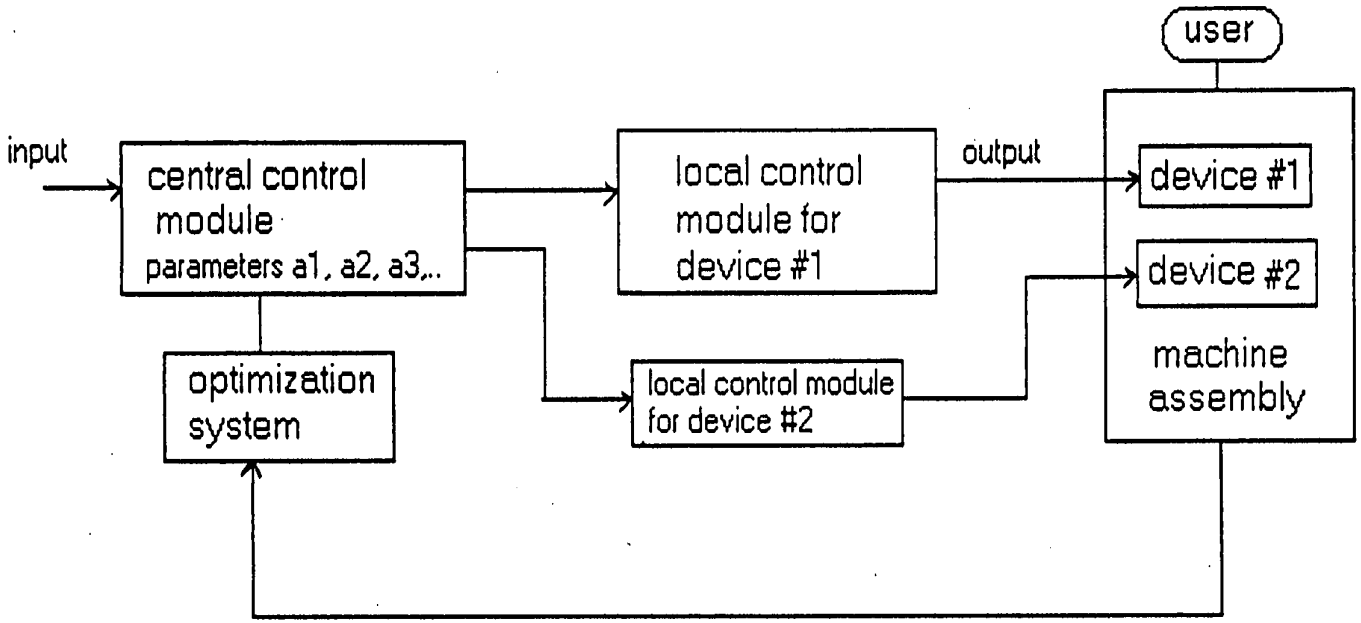
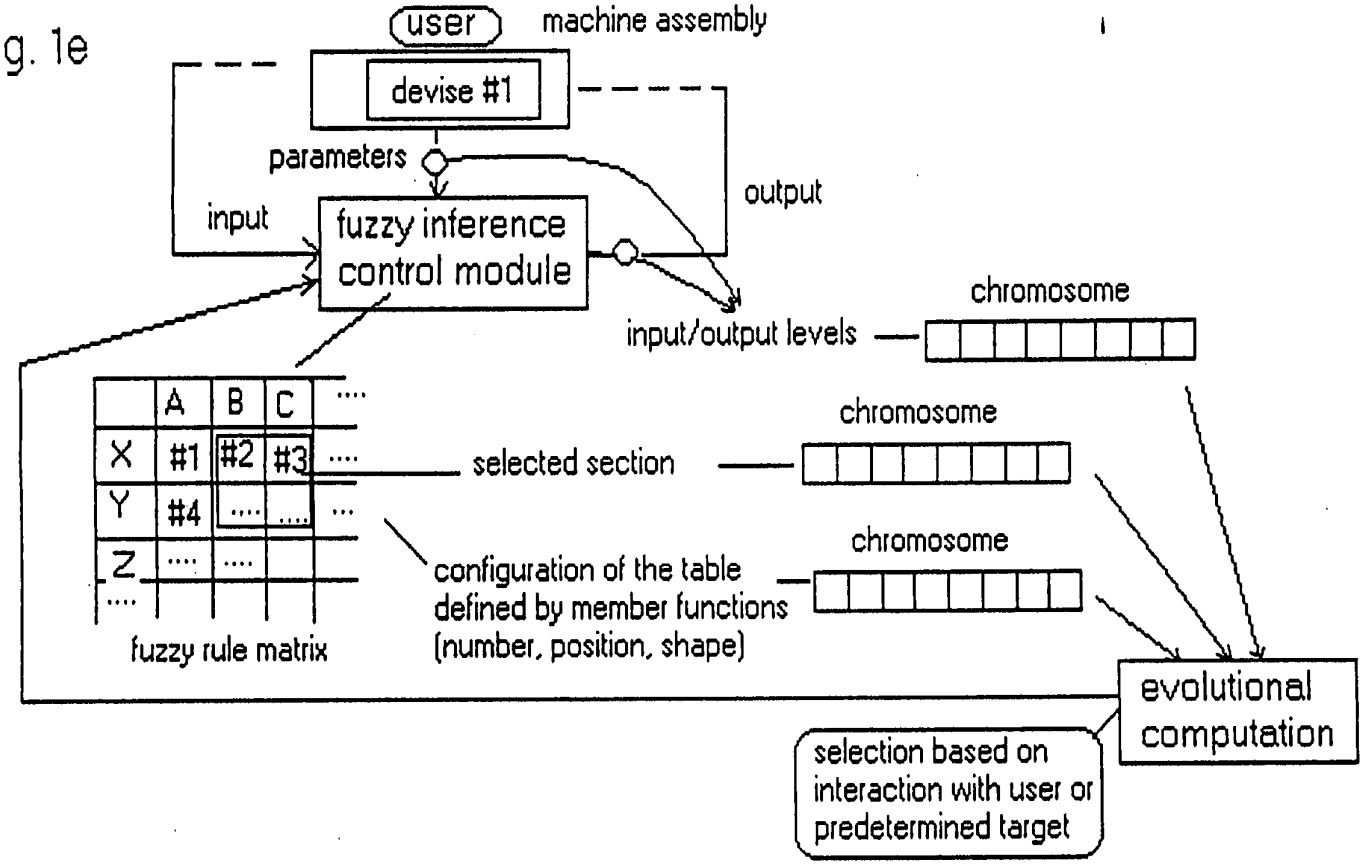

user
input
central control module
parameters a1, a2, a3,..
local control module for device #1
output
device #1
device #2
machine assembly
optimization system
local control module for device #2

Fig. 1e


user
machine assembly
devise #1
parameters
output
input
fuzzy inference control module
chromosome
input/output levels
A
B
C
X
#1
#2
#3
Y
#4
Z
selected section
chromosome
configuration of the table defined by member functions (number, position, shape)
chromosome
fuzzy rule matrix
evolutional computation
selection based on interaction with user or predetermined target

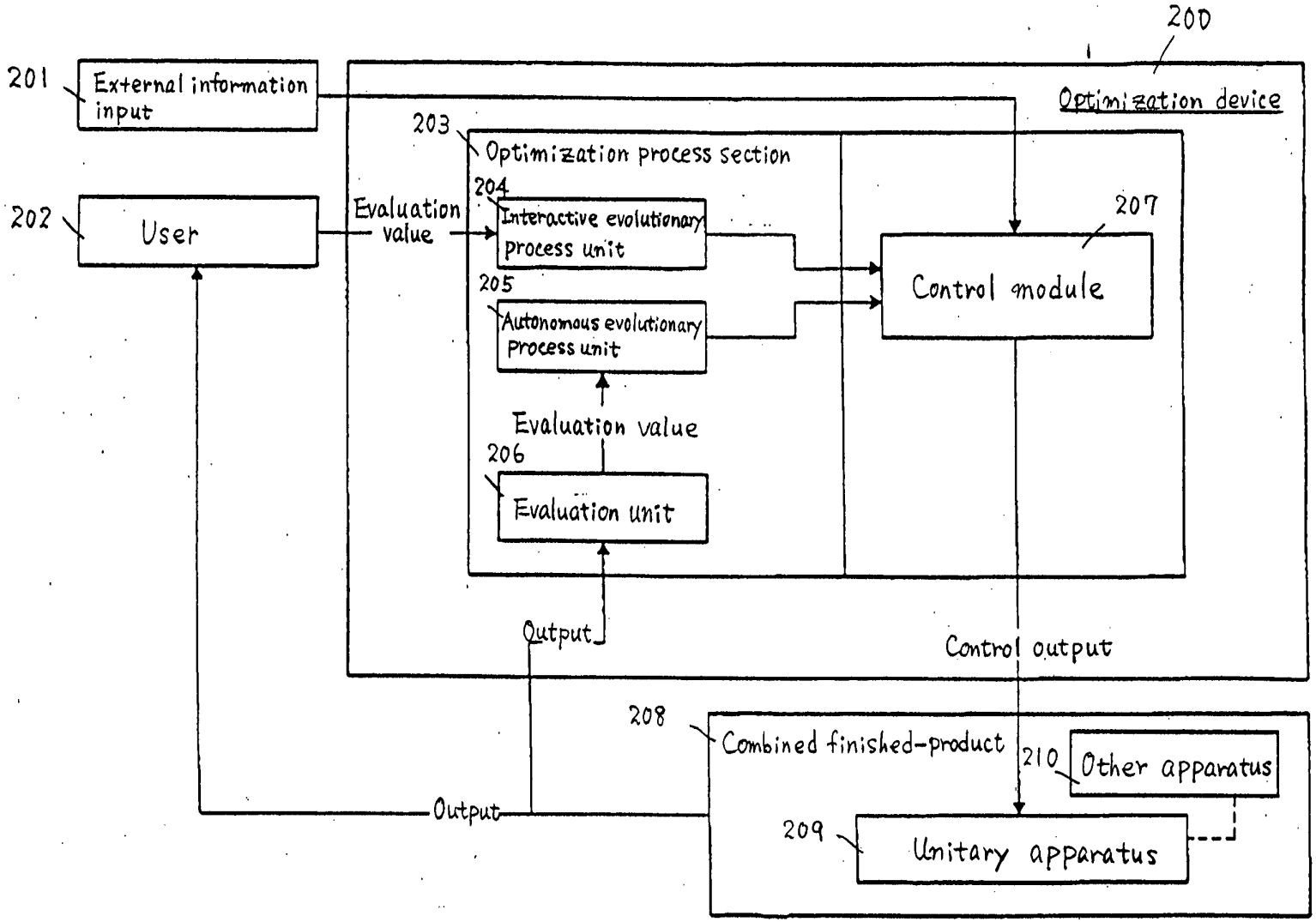

200
Optimization device
201
External information input
202
User
203
Optimization process section
204
Interactive evolutionary process unit
205
Autonomous evolutionary Process unit
206
Evaluation unit
207
Control module
Evaluation value
Evaluation value
Output
Control output
208
Combined finished-product
210
Other apparatus
209
Unitary apparatus
Output

FIG. 2

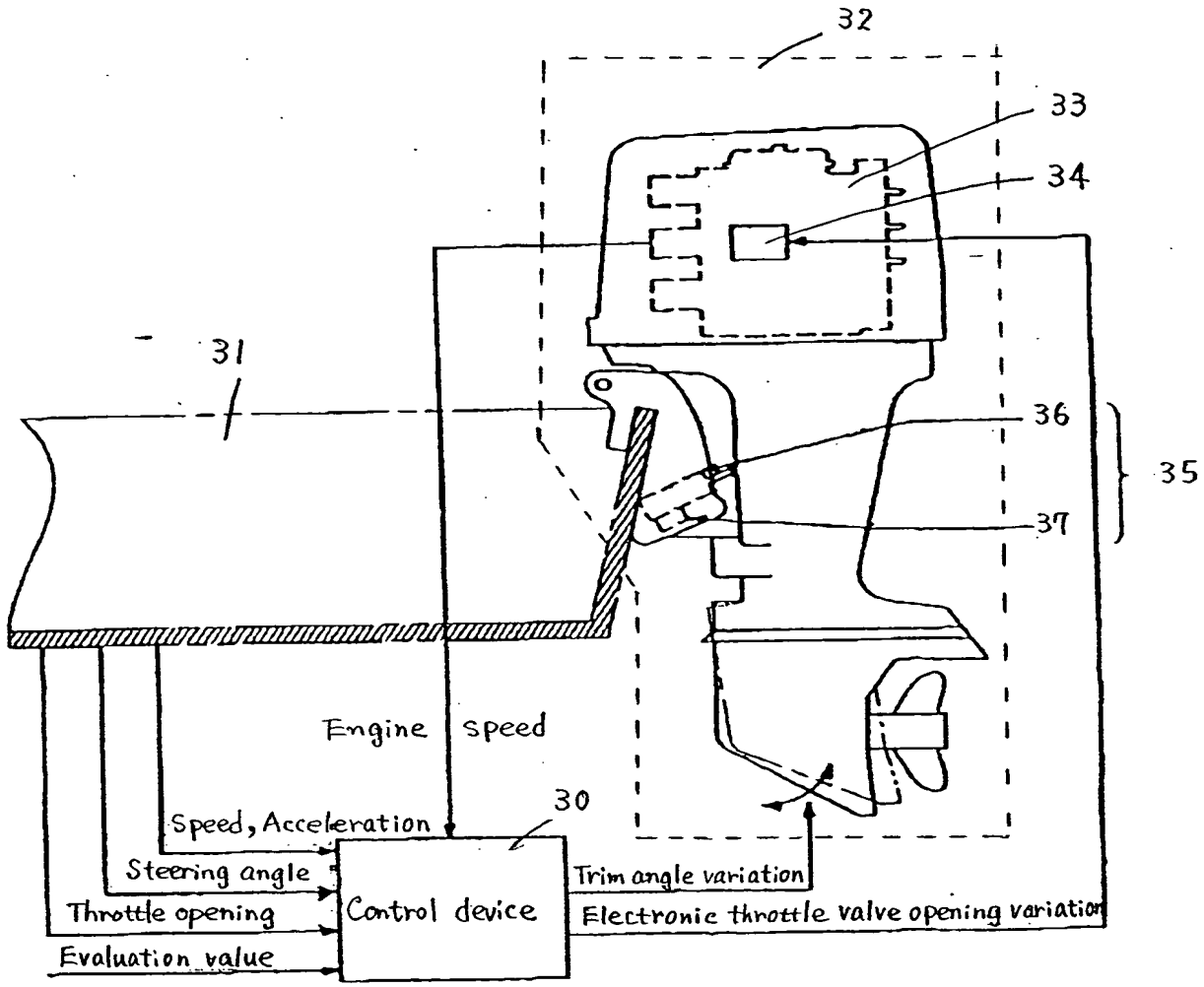

32
33
34
31
36
35
37
Engine speed
30
Speed, Acceleration
Steering angle
Throttle opening
Evaluation value
Control device
Trim angle variation
Electronic throttle valve opening variation

FIG. 3

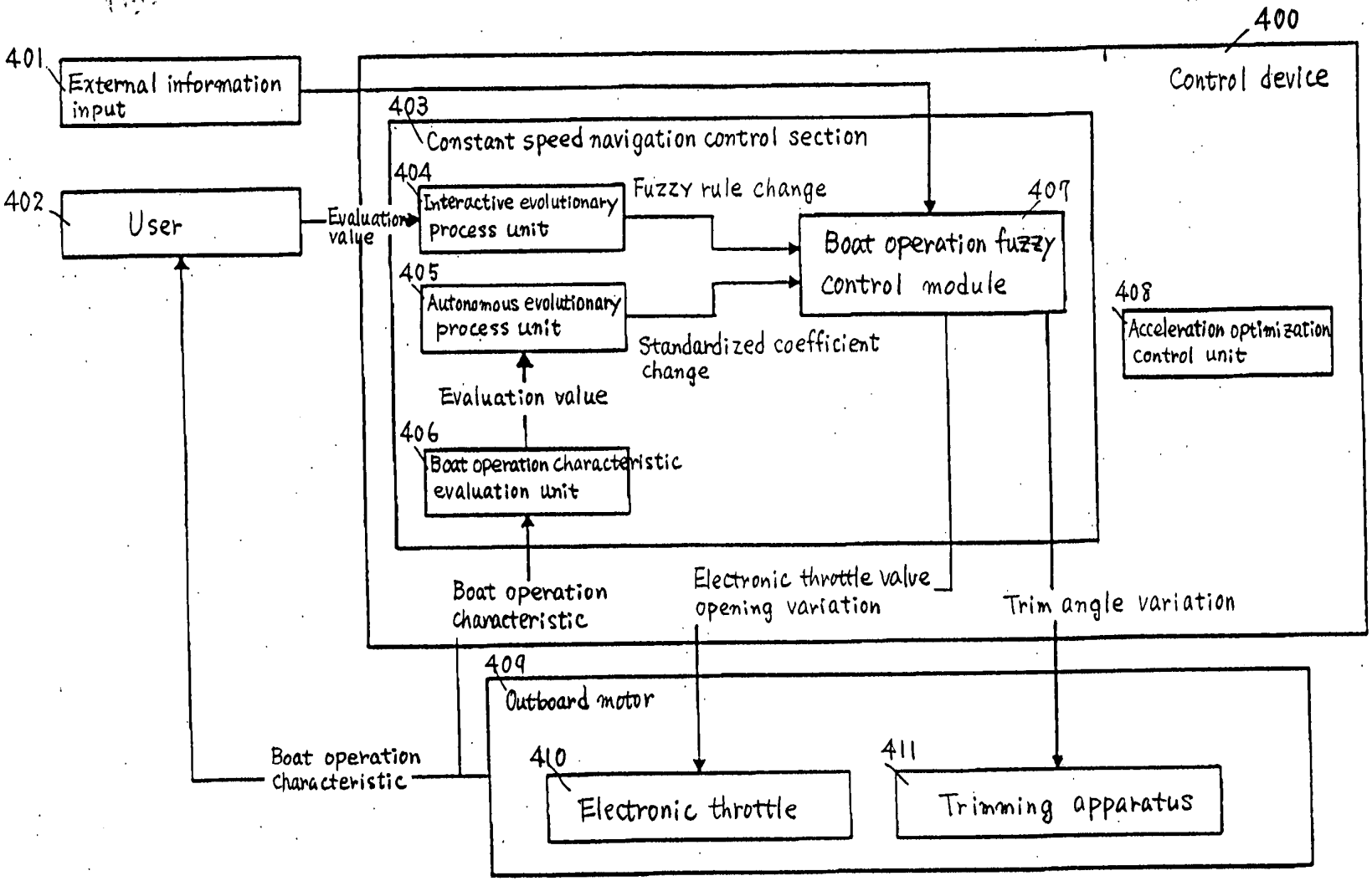

400
Control device
401
External information input
403
Constant speed navigation control section
402
User
Evaluation value
404
Interactive evolutionary process unit
Fuzzy rule change
407
Boat operation fuzzy control module
405
Autonomous evolutionary process unit
Standardized coefficient change
408
Acceleration optimization control unit
Evaluation value
406
Boat operation characteristic evaluation unit
Boat operation characteristic
Electronic throttle valve opening variation
Trim angle variation
409
Outboard motor
Boat operation characteristic
410
Electronic throttle
411
Trimming apparatus

FIG. 4

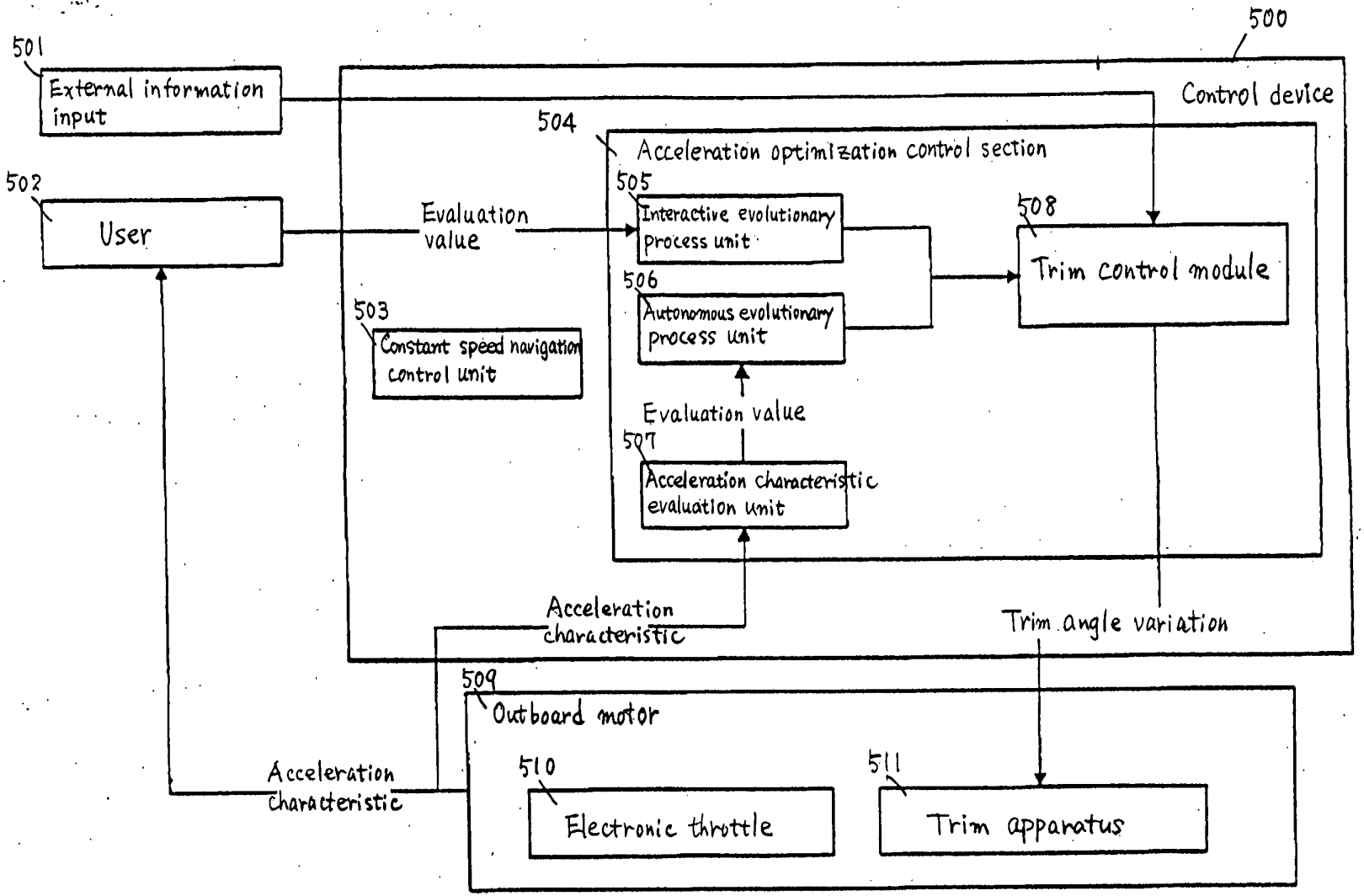
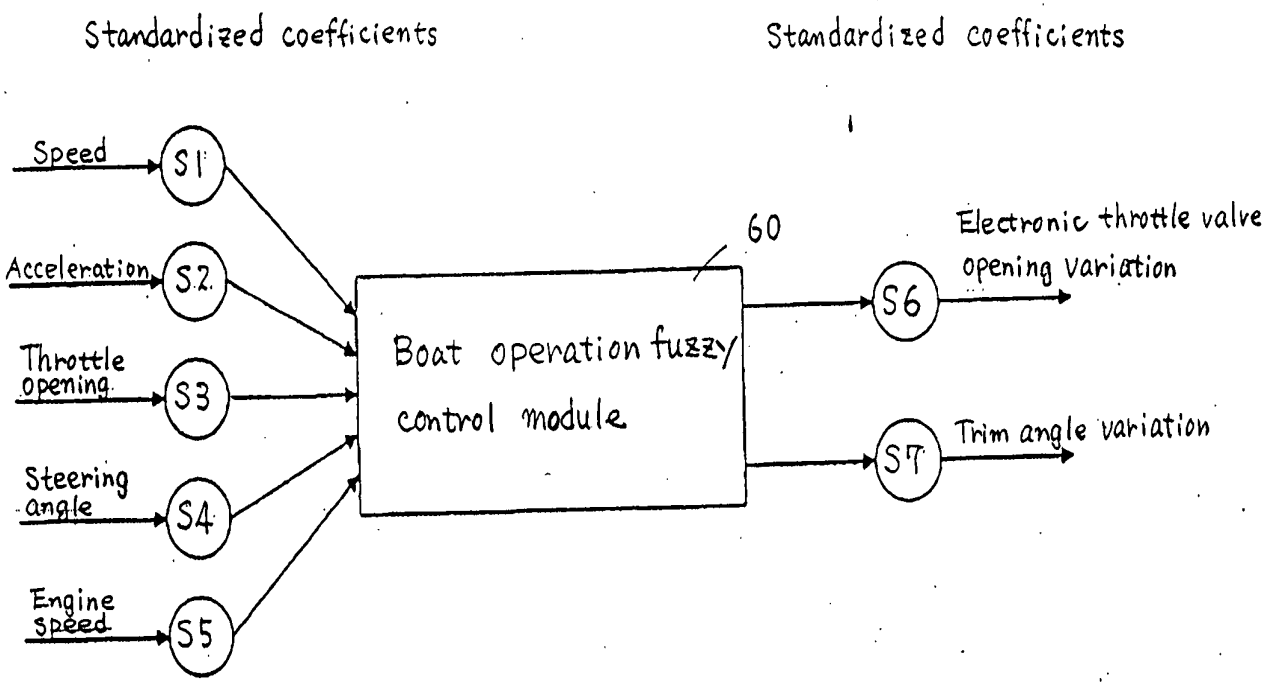

500
501
External information input
Control device
504
Acceleration optimization control section
502
User
Evaluation value
505
Interactive evolutionary process unit
508
Trim control module
506
Autonomous evolutionary process unit
503
Constant speed navigation control unit
Evaluation value
507
Acceleration characteristic evaluation unit
Acceleration characteristic
Trim angle variation
509
Outboard motor
Acceleration characteristic
510
Electronic throttle
511
Trim apparatus

FIG. 5



S1	S2	S3	S4	S5	S6	S7

FIG. 6

Speed

Acceleration

	FAST	MID	SLOW
PL	−10°	−5°	−1°
PS	−5°	−1°	0°
ZR	−1°	① 0°	③ +1°
NS	0°	② +1°	④ +5°
NL	+1°	+5°	+10°

Fuzzy rule table

input: Speed, Acceleration

output: Electronic throttle valve opening variable

Extraction →

①	②	③	④
0°	+1°	+1°	+5°

Perturbation with normalized random numbers added ↓

+0.5°	+1.3°	+0.4°	+6.1°
−0.3°	+1.4°	+2.0°	+4.9°
+0.9°	+0.6°	+1.5°	+5.2°

FIG. 7

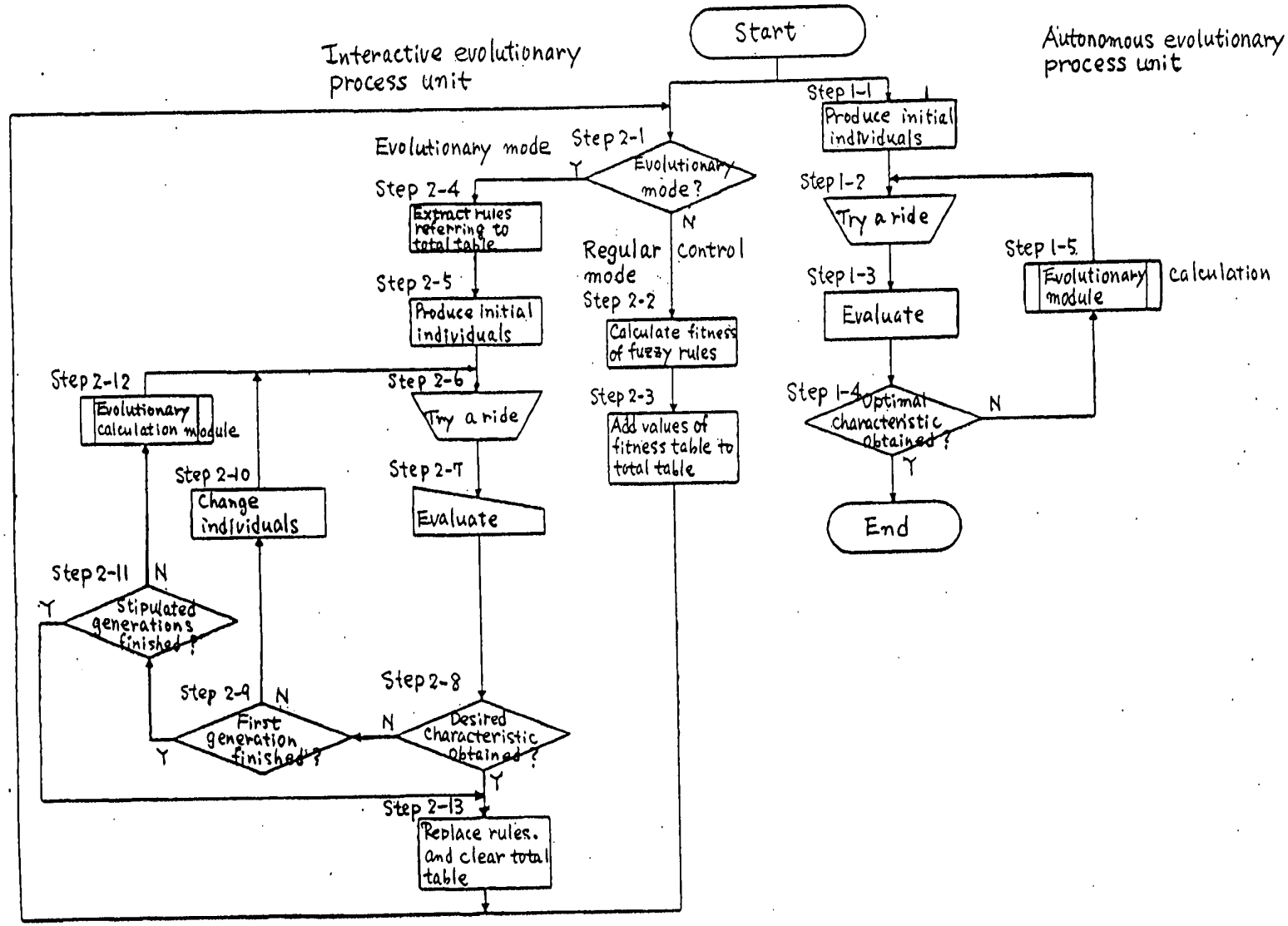

Start
Interactive evolutionary process unit
Autonomous evolutionary process unit
Step 1-1
Produce initial individuals
Step 1-2
Try a ride
Step 1-3
Evaluate
Step 1-4
Optimal characteristic obtained?
N
Y
Step 1-5
Evolutionary module
calculation
End
Evolutionary mode
Step 2-1
Evolutionary mode?
Y
N
Regular mode control
Step 2-2
Calculate fitness of fuzzy rules
Step 2-3
Add values of fitness table to total table
Step 2-4
Extract rules referring to total table
Step 2-5
Produce initial individuals
Step 2-6
Try a ride
Step 2-7
Evaluate
Step 2-8
Desired characteristic obtained?
N
Y
Step 2-9
First generation finished?
N
Y
Step 2-10
Change individuals
Step 2-11
Stipulated generations finished?
N
Y
Step 2-12
Evolutionary calculation module
Step 2-13
Replace rules. and clear total table

FIG. 8

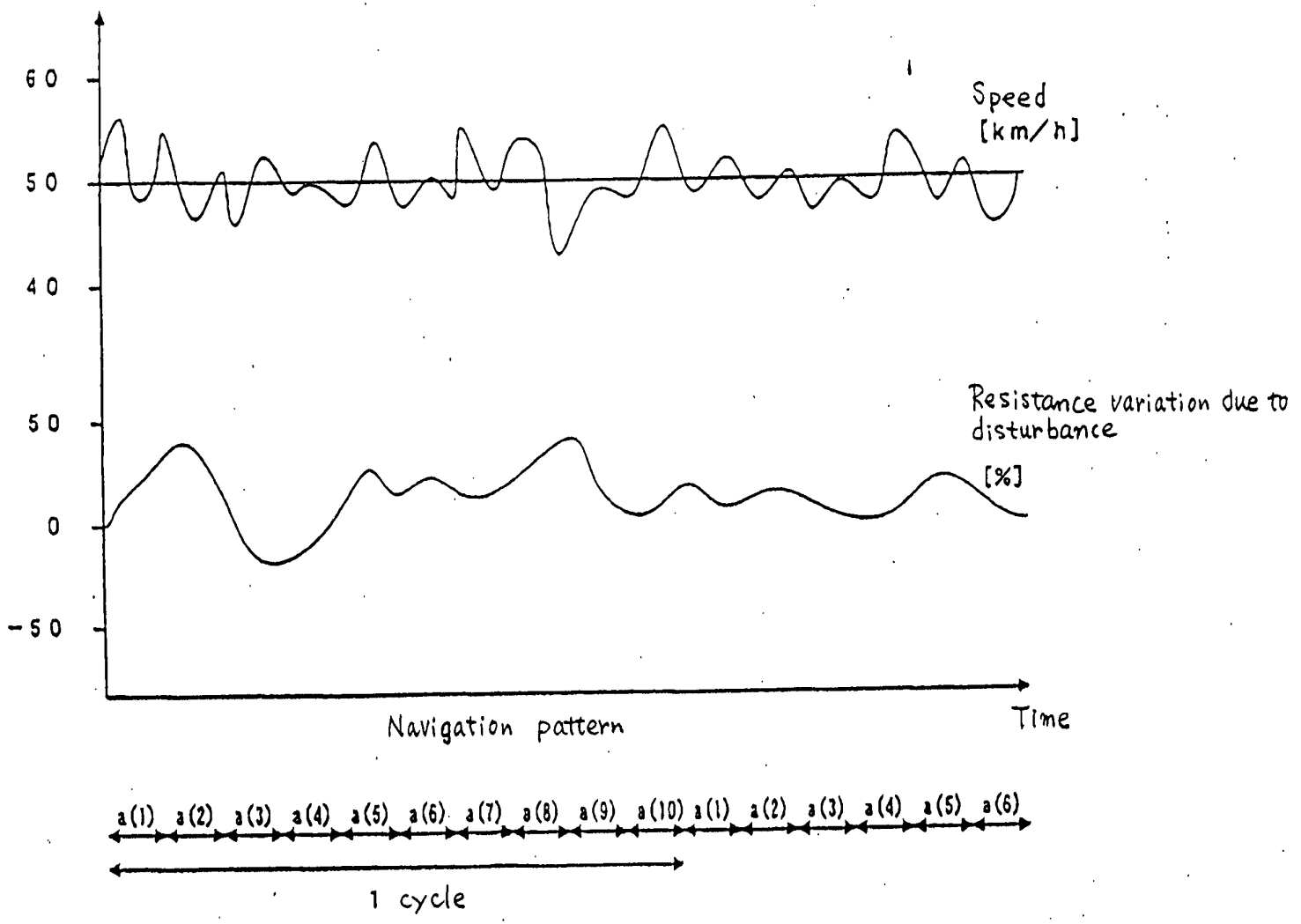

60
50
40
50
0
-50
Speed
[km/h]
Resistance variation due to disturbance
[%]
Navigation pattern
Time
a(1) a(2) a(3) a(4) a(5) a(6) a(7) a(8) a(9) a(10) a(1) a(2) a(3) a(4) a(5) a(6)
1 cycle

FIG. 9

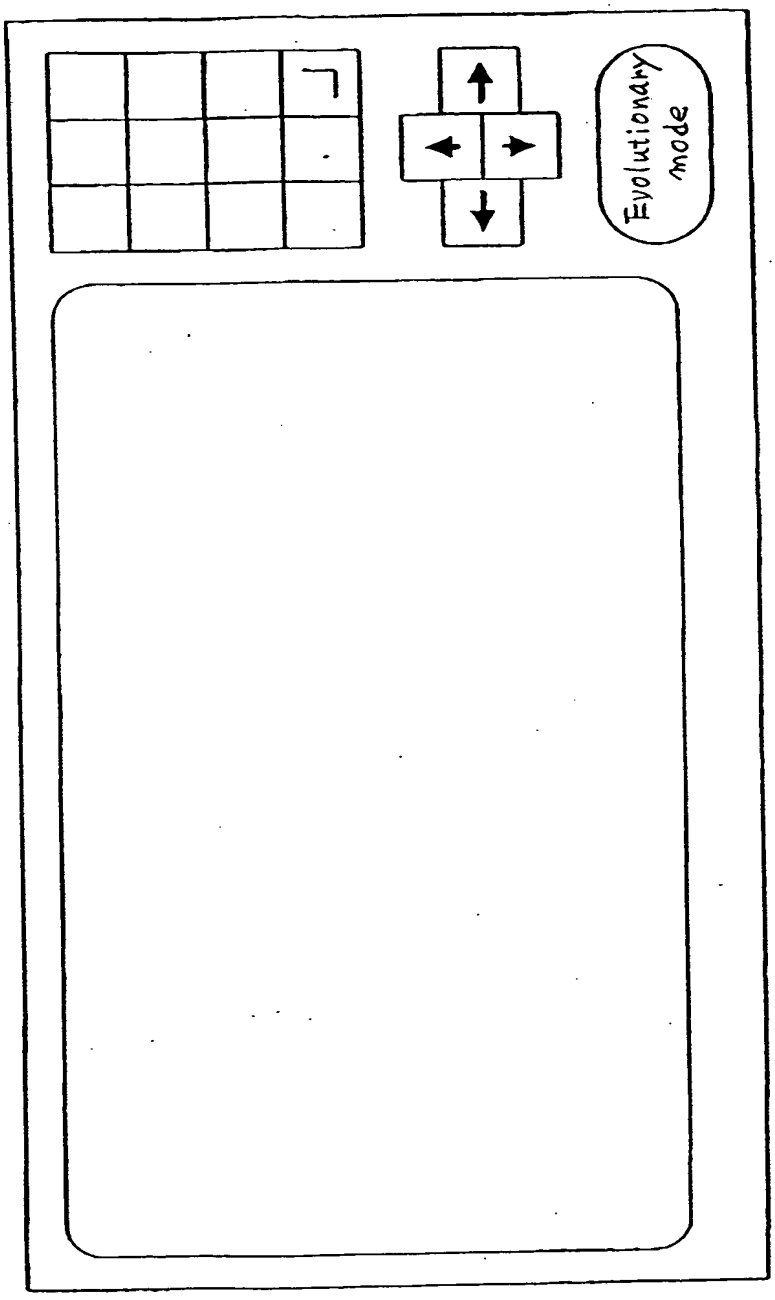


FIG. 10

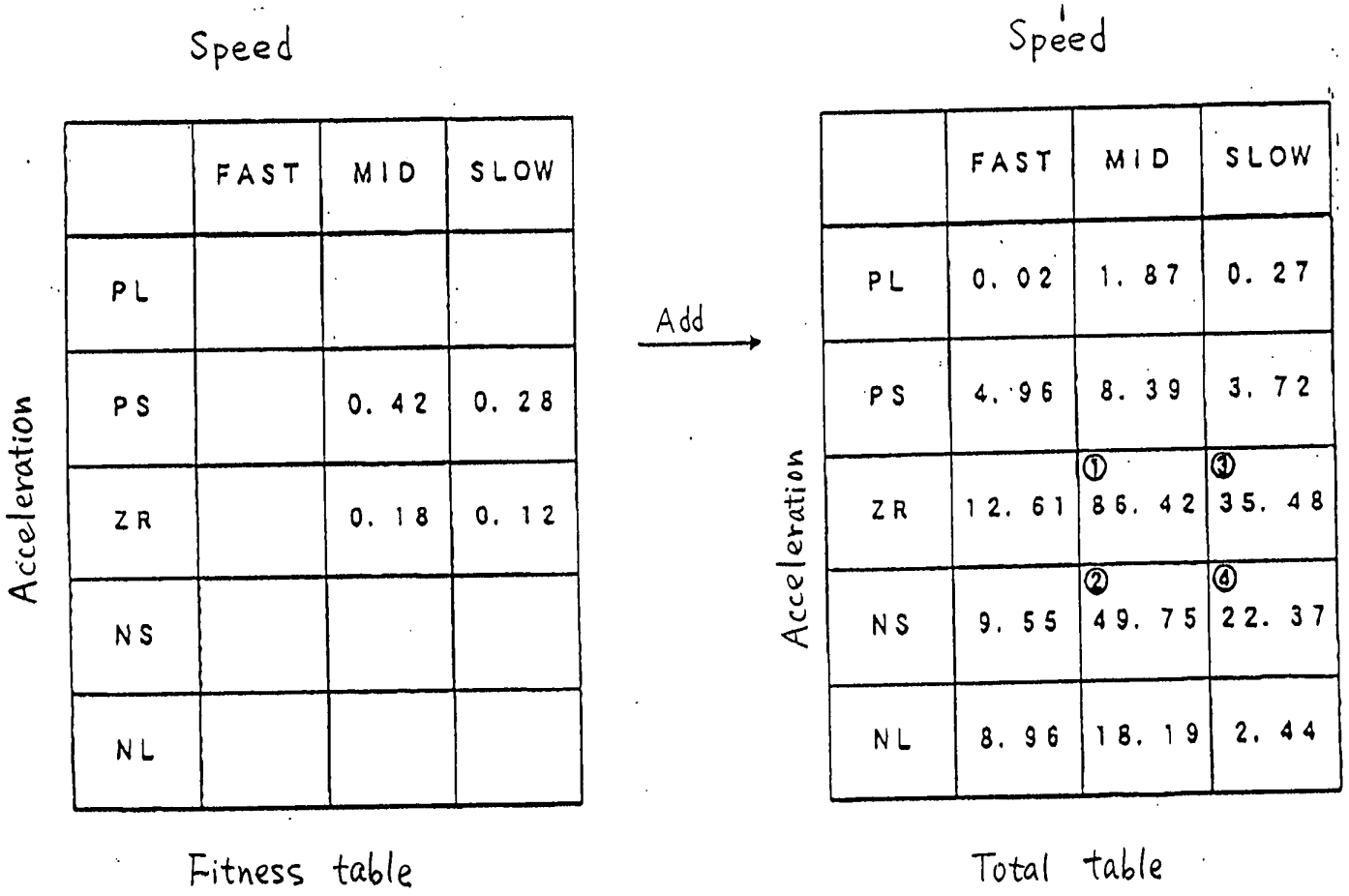

Speed
Acceleration
FAST
MID
SLOW
PL
PS
ZR
NS
NL
0. 42
0. 28
0. 18
0. 12
Fitness table
Add
Speed
Acceleration
FAST
MID
SLOW
PL
0. 02
1. 87
0. 27
PS
4. 96
8. 39
3. 72
ZR
12. 61
① 86. 42
③ 35. 48
NS
9. 55
② 49. 75
④ 22. 37
NL
8. 96
18. 19
2. 44
Total table

FIG. 11

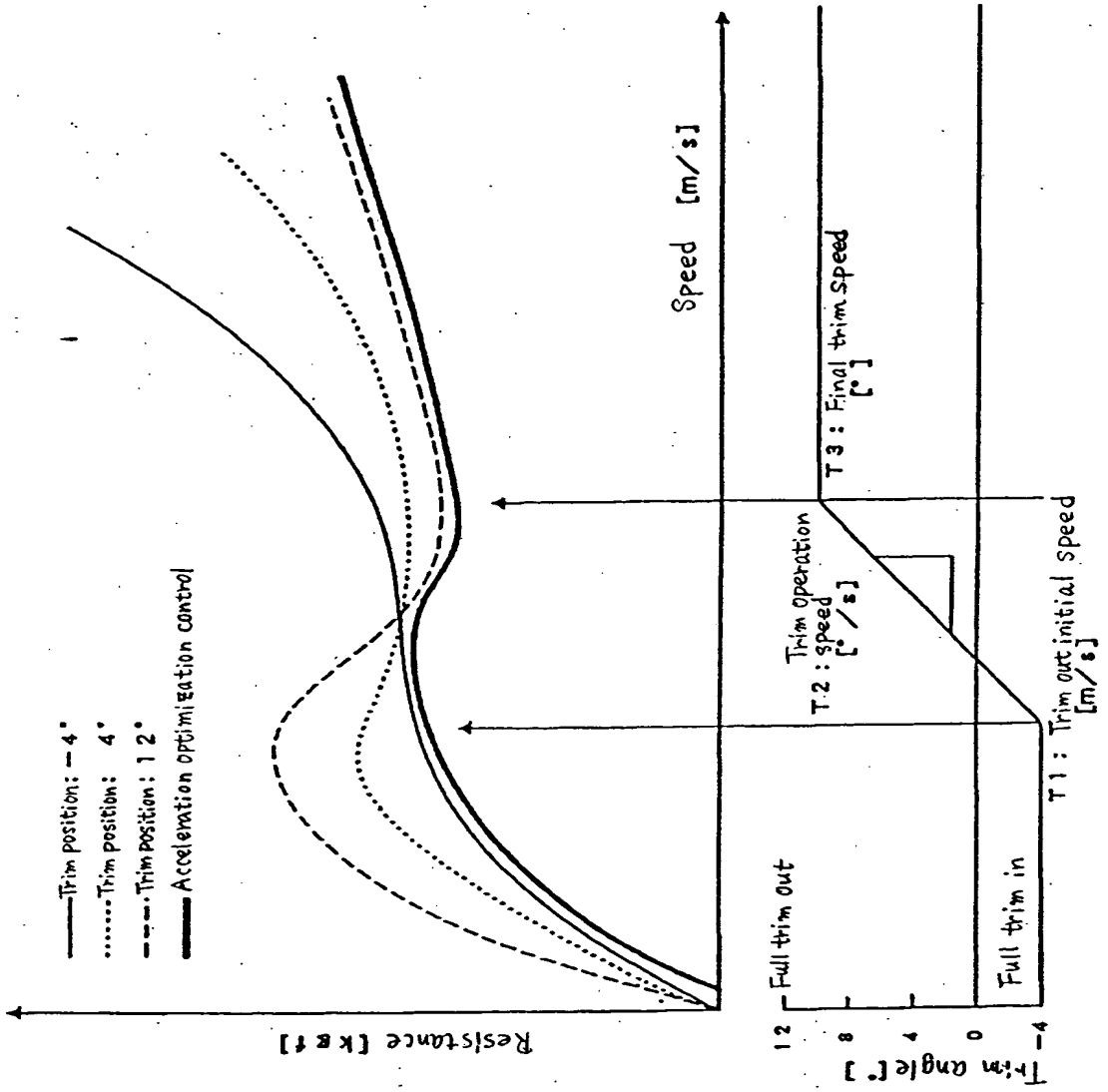

Trim position: −4°
Trim position: 4°
Trim position: 12°
Acceleration optimization control
Resistance [kgf]
Speed [m/s]
T1 : Trim out initial speed [m/s]
T2 : Trim operation speed [°/s]
T3 : Final trim speed [°]
Full trim out
Full trim in
Trim angle [°]
12
8
4
0
−4

FIG. 12

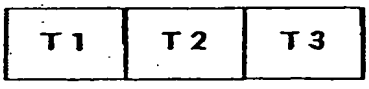

T1
T2
T3

FIG. 13

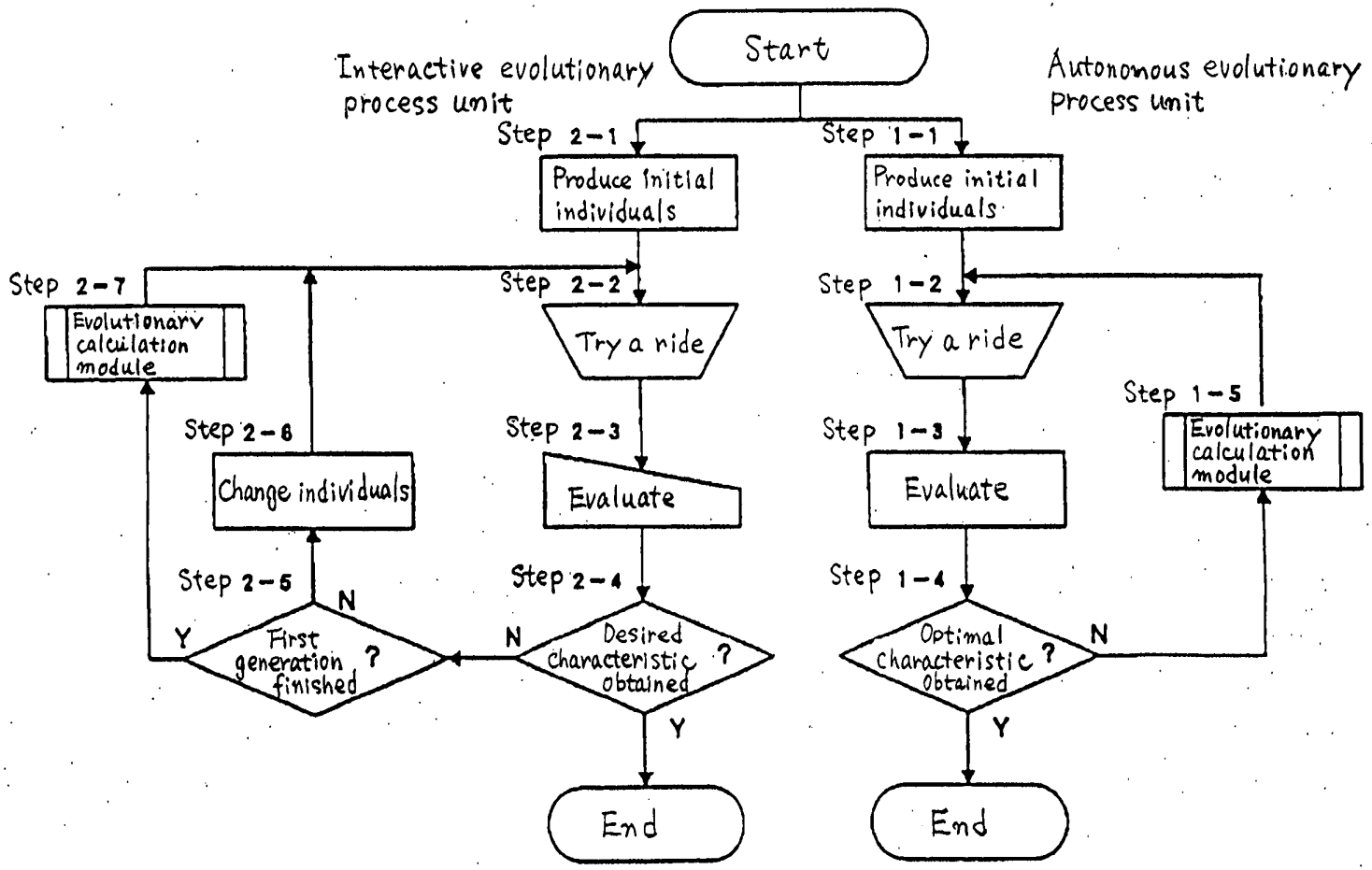

Start
Interactive evolutionary process unit
Autonomous evolutionary process unit
Step 2-1
Produce initial individuals
Step 1-1
Produce initial individuals
Step 2-7
Evolutionary calculation module
Step 2-2
Try a ride
Step 1-2
Try a ride
Step 1-5
Evolutionary calculation module
Step 2-6
Change individuals
Step 2-3
Evaluate
Step 1-3
Evaluate
Step 2-5
First generation finished ?
N
Y
Step 2-4
Desired characteristic obtained ?
N
Y
Step 1-4
Optimal characteristic obtained ?
N
Y
End
End

FIG. 14

Evolutionary computation module (GA)

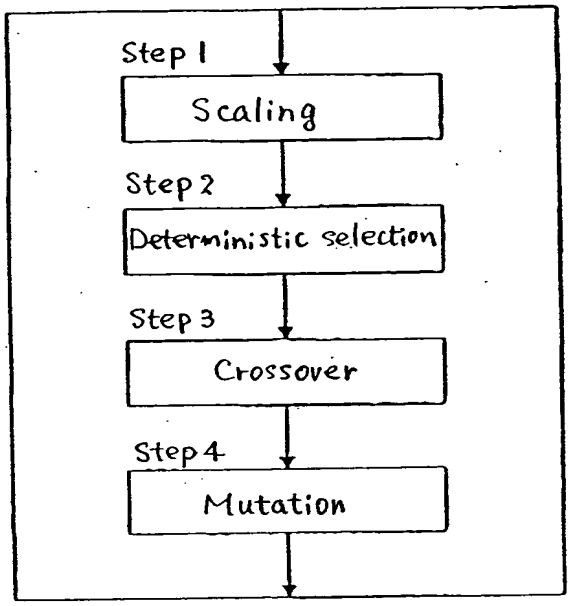


FIG. 15

Evolutionary computation module (ES)

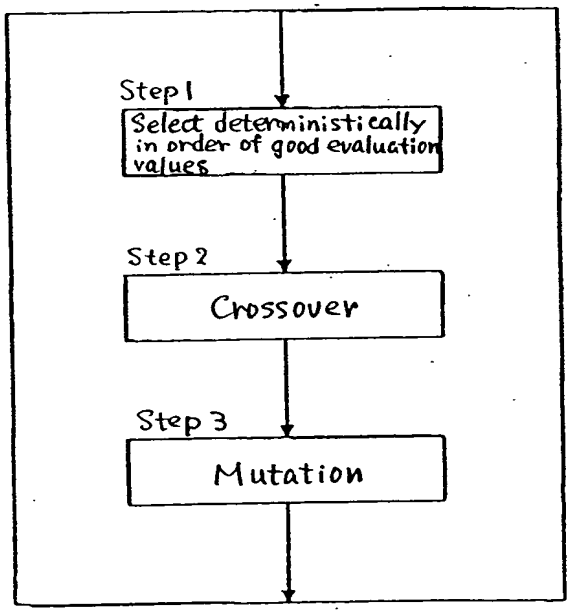


FIG. 16

Evolutionary computation module (EP)

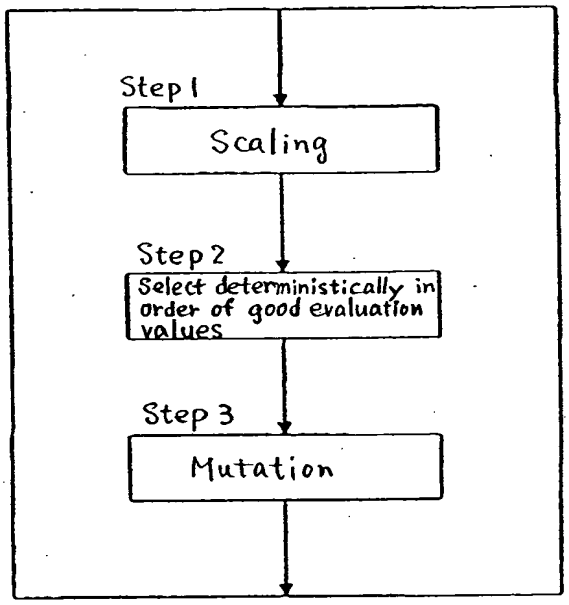


FIG. 17

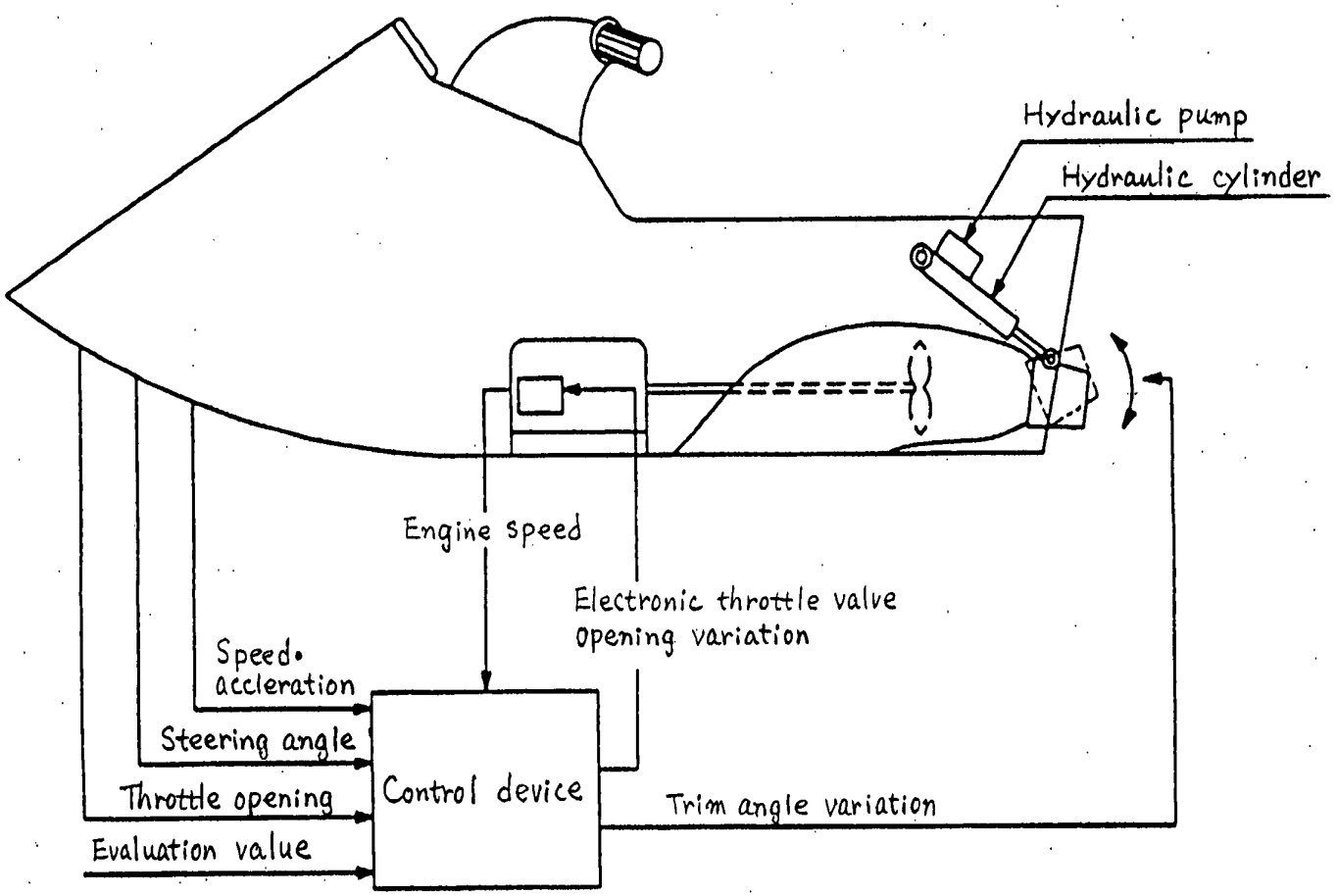

Hydraulic pump
Hydraulic cylinder
Engine speed
Electronic throttle valve
Opening variation
Speed•
accleration
Steering angle
Throttle opening
Evaluation value
Control device
Trim angle variation

FIG. 18

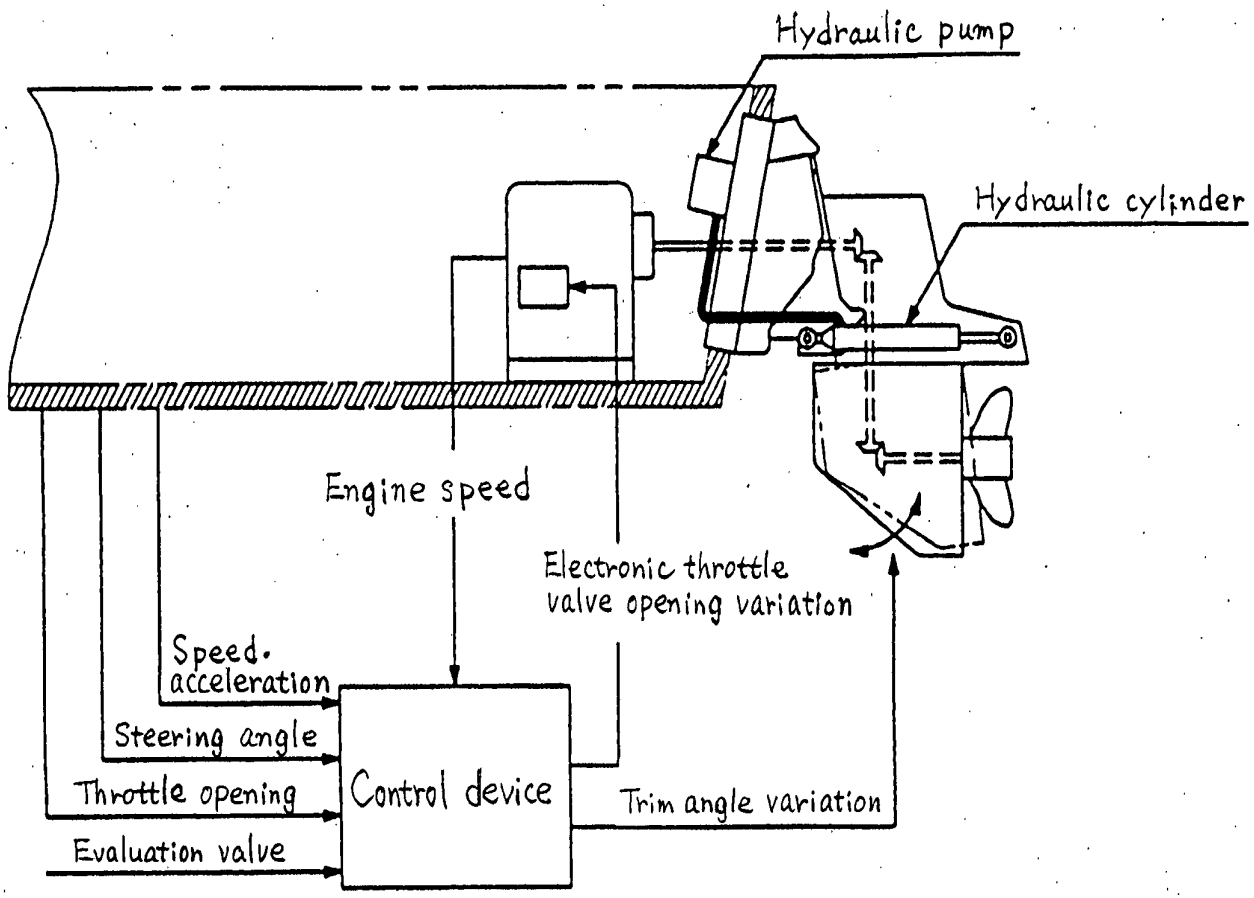

Hydraulic pump
Hydraulic cylinder
Engine speed
Electronic throttle
valve opening variation
Speed.
acceleration
Steering angle
Throttle opening
Evaluation valve
Control device
Trim angle variation

FIG. 19

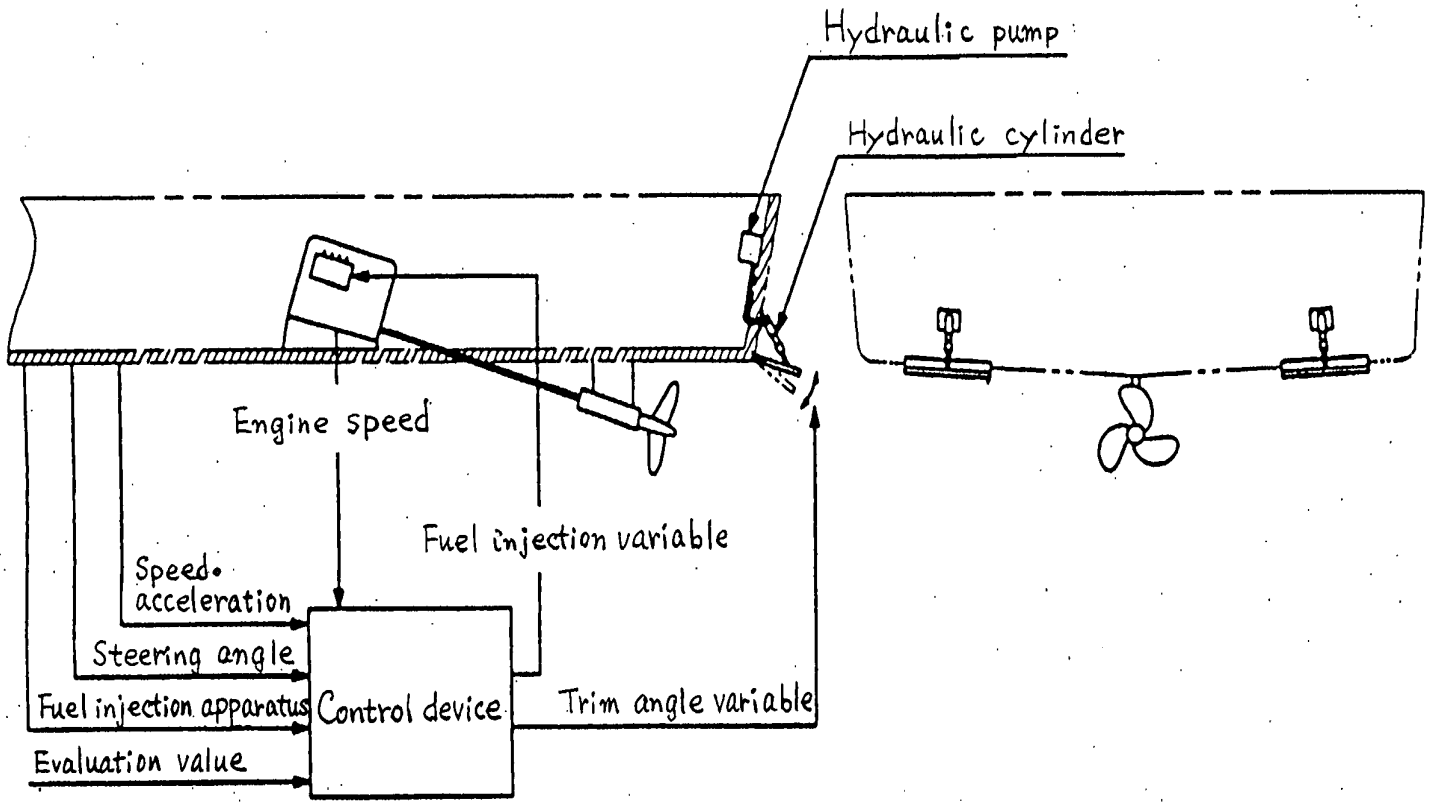

Hydraulic pump
Hydraulic cylinder
Engine speed
Fuel injection variable
Speed•
acceleration
Steering angle
Fuel injection apparatus
Evaluation value
Control device
Trim angle variable

FIG. 20

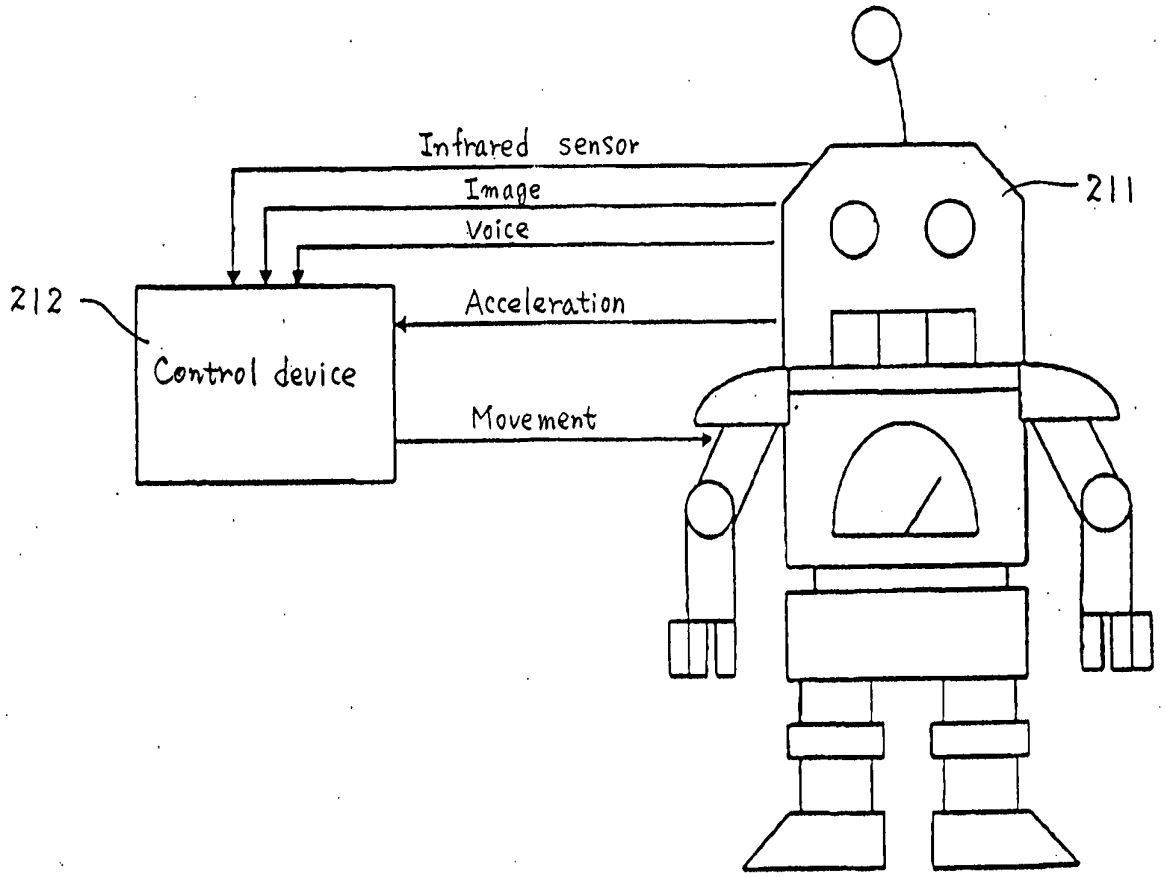

Infrared sensor
Image
Voice
Acceleration
Movement
212
Control device
211

FIG. 21

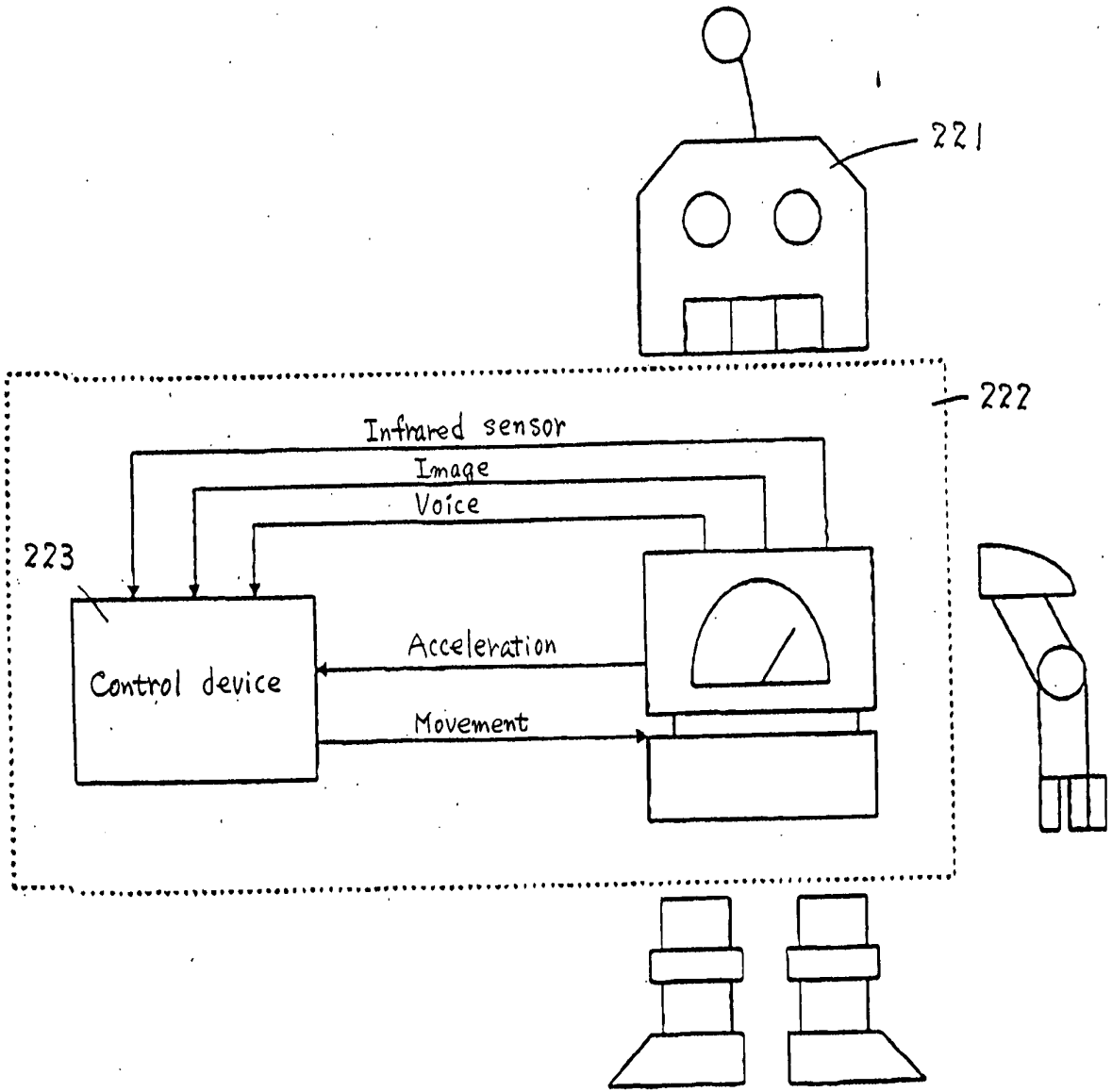

221
222
Infrared sensor
Image
Voice
223
Control device
Acceleration
Movement

FIG. 22

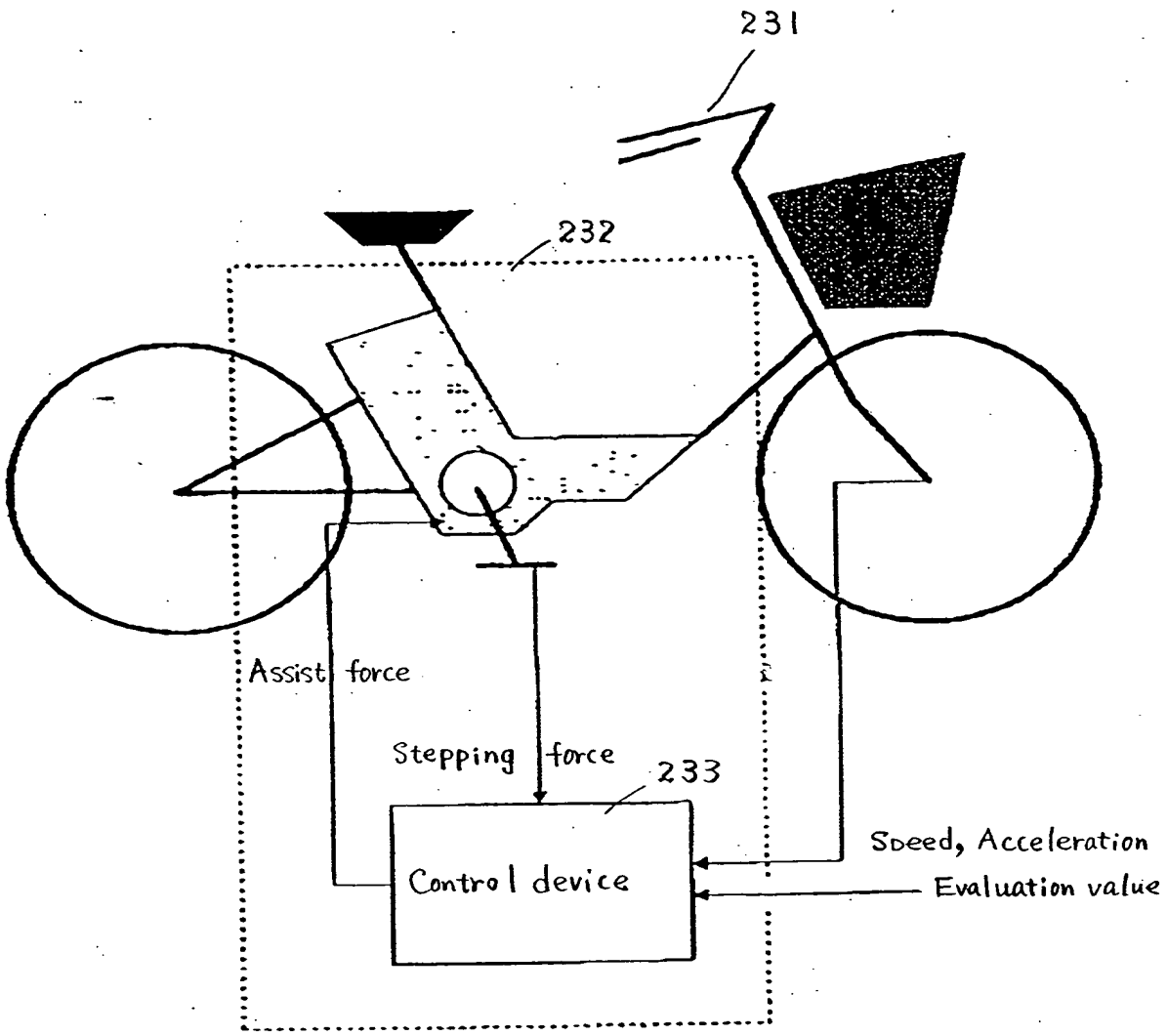

231
232
Assist force
Stepping force
233
Control device
Speed, Acceleration
Evaluation value

FIG. 23